



FIGS. 1–4. *Dichrorampha acuminatana*. 1, Wings of male from Steuben, ME. 2, Wings of male from Apetlon, Austria. 3, Genitalia of male from Steuben, ME. 4, Genitalia of male from Apetlon, Austria. Further details are in the Specimens examined section of the text.

The species is widely distributed in western and central Europe (Razowski 1996). Two Palearctic congeners, *D. vancouverana* McDunnough (= *D. gueneana* Obraztsov) and *D. petiverella* (L.), were previously reported in Maine (Roberts 1991), and subsequent collecting there has revealed well established populations of these species along the immediate coastline wherever undisturbed stands of their native or naturalized foodplant *Achillea millefolium* L. (Asteraceae) occur. With captures of *D. vancouverana* in the Pacific Northwest (Miller 1999), coastal distribution patterns of the two holarctic congeners continue to suggest they are immigrants, although the possibility cannot be ruled out that they represent spotty relicts of circumpolar distributions.

**Specimens examined.** ♂, Steuben, ME (Fig. 1), M. A. Roberts, 15/06/2001, genit. slide prep. MAR2027M (Fig. 3), forewing length 7.0 mm, in M. A. Roberts collection, Steuben, ME; ♂, Wangeroo, Ostfries. Inseln [Germany], 07/09/1949, E. Jäckh, genit. prep. on pin, forewing length 6.0 mm; ♂, Kelheim, Obfrk. [Germany], 03/08/1952, Jäckh, genit. prep. on pin, forewing length 6.0 mm; ♂, Hannover, Misb Moor [Germany], 29/05/1931, genit. slide prep. WEM 612011, forewing length 6.5 mm; ♂, Apetlon, Burgenland [Austria] (Fig. 2), 11/09/1971, E. Jäckh,

genit. slide prep. WEM612012 (Fig. 4), forewing length 5.5 mm. The four Palearctic specimens are in the U.S. National Museum of Natural History (USNM), Washington, D.C.; we thank J. W. Brown for loaning them.

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Received for publication 8 April 2002; revised and accepted 11 November 2002.

#### HOST PLANT ASSOCIATIONS OF WESTERN SPECIES OF *PAPAIPEMA* (NOCTUIDAE) WITH PARTICULAR REFERENCE TO THE APIACEOUS PLANTS

**Additional key words:** host plants, Apiaceae, Asteraceae, polyphagy.

The genus *Papaipema* Smith (Noctuidae) is the largest noctuid genus endemic to North America has long been a favorite among students of lepidopteran life history (e.g., Kwiat 1916, Hessel 1954). With 46 described species and at least 5 undescribed species of which we are, *Papaipema* is the fifth most speciose noctuid genus on this continent (Hodges 1983), super-

seeded only by the Holarctic genera *Acrionicta* Ochs. (n = 81 Nearctic species), *Catocala* Schrank (n = 110), *Lacinipolia* McDunnough (n = 57), and *Schinia* Hübner (n = 123 species in North America) (Hodges 1983). *Papaipema* currently includes 46 valid described species, at least five undescribed species (Quinter, in MS), and two valid subspecific entities,

*Papaipema baptisiae baptisiae* (Bird) and *Papaipema b. limata* Bird (E.L. Quinter, in Hodges 1983).

*Papaipema* and its relatives form a putatively monophyletic clade of endophagous plant borers in the Apameini (sensu Hodges 1983). Whereas most of the species in this tribe are associated with monocotyledonous plants, species of *Papaipema* feed and specialize on members of between 22 and 25 plant families (Goldstein 1999). Though well studied, a number of questions remain concerning host plant associations in this group, especially among the relatively few western species (*Papaipema* attains its highest regional diversity in the eastern United States). In this paper, we present life history data based on recent collecting and rearing efforts for species belonging to the *Papaipema birdi* (Dyar 1908) and *Papaipema harrisi* Grote species complexes, and summarize the known host associations for the remaining western *Papaipema* species and those associated with Apiaceae regardless of geography. Our observations bear on the evolution of umbellifer-feeding in Lepidoptera, and *Papaipema* in particular and possibly the role of coumarin compounds in mediating the evolution of host association (e.g., Berenbaum 1981, 1983). We also discuss collecting and rearing efforts on eastern umbel-feeding *Papaipema* species. All larvae encountered were reared on artificial diet, and adult specimens deposited at AMNH and FMNH.

**Apiaceous host plant records for *Papaipema* species.** A few species of *Papaipema* are known to feed on apiaceous plants, and although at least three of these (*P. birdi*, *P. harrisi* and *P. eryngii* Bird) appear to be specialists on Apiaceae, the others exhibit a broader range of apiaceous and non-apiaceous host use. The *P. birdi* complex includes an eastern species (*P. birdi*) and two western species (*P. pertincta* Dyar and *P. insulidens* [Bird]), all of which are associated with the Apiaceae (=Umbelliferae). *Papaipema birdi* has been considered oligophagous specialist on apiaceous plants, its primary host being the water hemlock *Cicuta maculata* L. Prior to the present study, other host records included *Sium suave* Walt. (Apiaceae), and "other umbellates" (Hessel 1954:60; treating *P. birdi* as a synonym of *P. marginidens*, of which there are no known host records), as well as several asteraeous plants (Kwiat 1916). The two other species in the *P. birdi* complex, *P. pertincta* and *P. insulidens*, each of which have been recorded from both apiaceous and non-apiaceous plants, are western species apparently separated by the Cascade Mountains, with *P. pertincta* to the west and *P. insulidens* to the east. A host of *P. insulidens* was described by Bird (1921, 1931) as a species of *Senecio* (Asteraceae). In the field

notes of his son (archived at the American Museum of Natural History), the late Junius Bird, the host plant was described as a "large, Dill-like weed," suggesting an apiaceous plant. The published association of *P. pertincta* with *Lupinus polyphyllus* Lindley (Fabaceae) (see Bird 1926) is curious because only two other *Papaipema* species are associated with fabaceous plants: the western *Papaipema angelica* with *Psoralea macrostachya* DC., and the eastern *Papaipema baptisiae* with *Baptisia tinctoria* (L.).

Outside the *Papaipema birdi* complex, umbellifer-feeding occurs in *Papaipema eryngii*, a threatened species restricted to prairie wetlands where it specializes on *Eryngium yuccifolium*, and in the *P. harrisi* group, comprising *P. harrisi* and *P. verona* Smith. Host records for *P. harrisi*, whose distribution suggest an association with *Heracleum lanatum* Michx. (Apiaceae) along the Atlantic Coast and an association with *Angelica atropurpurea* L. (Apiaceae) westward following the Great Lakes (Kwiat 1916, Hessel 1954, Jones & Kimball 1943, Quinter unpublished data). Both of these host species are apiaceous plants. In the Northeast, it is thought that *P. birdi* and *P. harrisi* segregate themselves according to host plant, with *P. birdi* confining itself to *Cicuta maculata* and *P. harrisi* to *Angelica atropurpurea* (see Kwiat 1916, Hessel 1954). *Papaipema verona*, for which we do not report novel host records, is a western species recorded primarily from species of the umbel genus *Heracleum*.

**Recent field collections.** During 1995, we examined several eastern USA sites for larvae of both *P. birdi* and *P. harrisi*. Visits to wetlands in western Connecticut and Massachusetts with dense populations of *Angelica atropurpurea* yielded only two *Papaipema* larvae (*Papaipema harrisi* has become decidedly rare in New England and is considered extirpated from Massachusetts). However, visits to a calcareous sedge-meadow complex in Otsego County, New York yielded more than two dozen *Papaipema* larvae from both *Angelica atropurpurea* and *Cicuta maculata*. All larvae collected from *C. maculata* and *A. atropurpurea* at the upstate New York site proved to be *P. birdi*. Although reports of "other umbellates" than *Cicuta maculata* and *Sium suave* occur in the literature (e.g., Kwiat 1916), our collections appear to be the first documentation of *Angelica atropurpurea* as a host for *P. birdi*. Although Kwiat (1916) reported non-apiaceous hosts for *P. birdi*, it is conceivable that the taxonomic confusion that typically surrounds *Papaipema* has resulted in erroneous reporting of hosts subsequent to that publication.

Our findings in the northwestern United States extended the known host ranges of *P. pertincta* and *P. in-*

TABLE 1. Collecting information and host associations of western *Papaipema* species discovered during this study.

Species	Locality	Life stage	Host plant	Dates
<i>P. pertincta</i>	Oregon: Tillamook Co.: Rt. 101, 1 mi S. of Wheeler	4 larvae	<i>Heracleum maximum</i>	8 July 1995
	Oregon: Clatsop Co.: Rt. 101, 8 mi. S. of Astoria (at jct. Rts. 101 & 30)	9 larvae, 1 pupa	<i>Cicuta douglasii</i>	8 July 1995
	Oregon Tillamook Co.: Rt. 101, 1–2 mi. N. of Manzanita	8 larvae	<i>Senecio vulgaris</i>	9–10 July 1995
		8 larvae	<i>Heracleum maximum</i>	
		4 larvae	<i>Ligusticum apifolium</i>	
		1 larva	Daucus sp.	
		8 larvae	<i>Cirsium</i> sp.	
	Oregon: Lincoln Co.; E. Devil's Lake Rd., 0.7 mi E. of Jct. Rt. 101	3 larvae	<i>Erechtites minima</i>	
		1 larva	<i>Cicuta douglasii</i>	11 July 1995
	Oregon: Tillamook Co.: Rt. 101, 12 S. of Jct. Rt. 22	6 larvae, 1 pupa	<i>Heracleum maximum</i>	11 July 1995
Oregon: Lincoln Co: Three Rocks Rd., 1.5 mi W. Rt. 101	1 larva	<i>Heracleum maximum</i>	13 July 1995	
<i>P. sauzalitae</i>	Oregon: Lincoln Co: Three Rocks Rd., 1.5 mi W. Rt. 101	1 larva	<i>Cirsium</i> sp.	13 July 1995
<i>P. insulidens</i>	Washington: Whitman Co: Steptoe Butte, el. 2500'–3000'	13 larvae	<i>Heracleum maximum</i>	15 July 1995

*insulidens*. These represent the least well-known *Papaipema* species for which published host records exist; their close resemblance to *P. birdi* as well as the informal description by Junius Bird of a "large, dill-like" host for *P. insulidens* suggested that apiaceous plants might fall within the host spectra of one or both of these two western species in the *birdi* complex. An additional southwestern species, *Papaipema angelica* Smith, 1899 has remained uncollected in recent decades despite our knowledge of its life history and host affiliation (Bird 1931). Although several dozen specimens of *P. pertincta* exist in the Oregon State University insect collection (which now includes the private collection of the late Elmer Griepentrog), we have been unable to verify the association of *P. pertincta* with any species of *Lupinus*. We thoroughly examined the botanical holdings at OSU to identify sites likely to support strong populations of various western lupines, but we found no *Papaipema* at any of these, and apparently no western collectors have observed or reared *P. pertincta* from *Lupinus* since Bird's (1926) second-hand account of the association. However, several dozen *P. pertincta* were reared from a variety of plants, mostly apiaceous, at six sites in Tillamook, Clatsop, and Lincoln counties (Table 1). Like its eastern relative *P. birdi*, *P. pertincta* appears to feed primarily in apiaceous plants; but unlike its eastern associate, *P. pertincta* also feeds in non-apiaceous plants.

In three weeks of field work in eastern Washington and Idaho, we failed to collect *P. insulidens* from its recorded host, *Senecio hydrophilus* Nutt. We examined sites suggested by the literature, museum labels, and the hand-written field notes and sketches of Ju-

nius Bird indicating large apiaceous host plants in Whitman County, Washington. Near localities visited by Junius Bird, several stands of *Conium maculatum* L. (Apiaceae), which matched his description and sketch, were checked without success. Thirteen larvae of *P. insulidens* were discovered and reared from *Heracleum maximum* Bartr. (Apiaceae) at Steptoe Butte at an elevation of 2500–3000'. Although we could not verify many published host associations of the two western members of the *Papaipema birdi* complex, we did take them on other hosts, apiaceous and otherwise. One possibility is that the dill-like host plant of *P. insulidens* referred to by Junius Bird was not apiaceous at all, but the introduced tansy ragwort *Senecio vulgaris*, one of the host plants from which we reared *P. pertincta*.

The reported host associations of the western *P. sauzalitae* (Grote) are atypically diverse for *Papaipema*, and include members of the asteraceous plant genera *Arctium*, *Cirsium*, and *Cynara* as well as *Castilleja* (Scrophulariaceae), and *Rumex* (Polygonaceae) (Crumb 1956). Peter McEvoy (pers. com.) of Oregon State University reports an association of *P. sauzalitae* with *Senecio* (Asteraceae) as well. Our collecting efforts yielded but a single specimen, from the exotic *Cirsium vulgare*. However, California material at the Essig Museum includes specimens from Inverness Park (Marin Co.) where larvae were observed in *Heracleum maximum*, *Artemisia douglasiana* Bess. in Hook. (Asteraceae), and *Ribes* sp. (Grossulariaceae), suggesting that *P. sauzalitae* may be polyphagous (J. Powell pers. com.). If this is the case, the member species of each of the primary umbellifer-feeding *Papaipema* species groups (the *harrisi-verona-sauzalitae*

complex and the *birdi-pertincta-insulidens* complex), have broadened their host usage to include both composites and umbels on the west coast.

The association of *P. pertincta* with apiaceous and non-apiaceous plants is noteworthy for two reasons. First, this species parallels *P. insulidens* in having a wider range of non-apiaceous recorded hosts than expected, given the apparently tighter associations of their eastern relatives (*P. birdi* and *P. sauzalita*, respectively) with umbels. Second, based on available DNA sequence data, *P. pertincta* is nearly indistinguishable from *P. birdi* (Goldstein 1999). We can not, therefore, rule out the possibility of *P. pertincta*'s feeding facultatively on *Lupinus*, though we were unable to recover larvae from any fabaceous plants and it is clear that the species is not thus restricted.

Although both facultative and obligate association with asteraceous plants is common among *Papaipema* species, umbel-feeding is less common. The parallel variation in host breadth among umbel-feeding *Papaipema* species is thus noteworthy, and suggests a profitable line of inquiry for further work on host use specialization in this group.

We thank P. McEvoy, E. Griepentrog, and J. Lattin for access to specimen material and assistance in locating collecting sites. J. Powell loaned material from the Essig Museum and shared his observations based on collecting and rearing efforts. We thank Kenneth and Elaine Bernard for lodging and permission to collect in their farm in Otsego Co., NY. This work was supported by an NSF doctoral dissertation improvement grant, an EPA graduate fellowship, and an AMNH Theodore Roosevelt Memorial Fund travel grant to PZG.

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*Received for publication 25 August 2002; revised and accepted 20 December 2002.*